Lean Production in SMEs – Diagnosis and Implementation Plan, a case study

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Abstract

The high industrial competitivity has dictated the development for this sector that allied with the inconstant and unstable economic environment make the companies very vulnerable and highly dependent of the surrounding market. This is a concern of special relevance for the SMEs and companies are increasingly adopting *Lean* solutions to continuously improve their operations.

The objective of this study is to diagnose a production system of an injection mold structure production factory. The diagnosis was focused on many aspects such as the part production lead time, a time study of the setups, the OEE determination for the CNC equipments and an analysis of the work stations. For the aspects that were analyzed during the diagnosis the problems are identified and the root causes determined. At the end of the diagnosis stage Lean solutions are proposed like new rules for production planning, setups procedures, 5S, and a Lean implementation plan that is adapted to the company of this case study. For some of the solutions an impact study with their implementation is made. Is also made an analysis of the success and unsuccess factors proposed in the bibliographic review that were verified during the diagnosis stage of the case study factory.

Keywords: Lean Manufacturing, SME, Lead time, setup, OEE, Lean implementation plan, production planning

1 Introduction

SMEs – small and medium sized enterprises - are increasing their presence in the industrial market. This allied with the unstable economic environment makes this companies highly dependent of the surrounding market. Thus, the constant improvement of the production systems, to produce more, with less resources and with better quality is a concern for most companies. Continuous improvement makes the companies better prepared to face the changes of the industry enabling them to face daily problems and getting a long-term vision.

Lean principles are well recognized by companies as a tool achieve their continuous improvement goals, both in management and productions areas. Lean implementation needs a total understanding of the system, identifying the added value chain and the waste sources. By doing this they can act in the waste sources, minimizing them or even eliminating them. Although, because lean birth relates to large enterprises, its application in SMEs is questioned by some investigators.

To understand the limitations of a lean implementation within SMEs, a bibliographic research was made. Several investigations were approached, and a convergent analysis was made for their findings.

This study aims to diagnosis a production system of a mold structures production company. A lean diagnosis was conducted for many aspects of the production area, such as part lead time, setups procedures, OEE – Overall Equipment Effectiveness – determination and an analysis for work stations was also conducted. At the end of the diagnosis stage several lean solutions were proposed and for some of them an impact study was made.

2 Bibliographic research

Because this study focusses on SMEs, it is important to define them. The SME definition varies according to country. European Commission issued a recommendation for the member states defining SME as a company that has between 10 and 250 workers and a business volume up to 50 million euros. Portuguese government followed the recommendation, but the German for instance, states that SME has up to 499 workers and a business volume up to 50 million euros. Outside Europe, the Chinese government states that SME may have up to 999 workers.

2.1 Lean in SMEs

Lean is a well-known key factor in repetitive production companies for improving their operations, although, because lean birth relates to large companies, many question its applicability in SMEs, stating that it is dependent of the company's size [1]. Investigations about lean implementation in SMEs are increasing, mostly due to increasing number of companies applying it to their production structure [2]. Studies show that SMEs apply lean principles mostly at operation level [3] and that this type of enterprises often choose to select techniques that carry less investment effort [4].

2.2 Success and unsuccess factor for Lean implementation

It is critical to understand what makes a SME to implement Lean principles to their operations, so an analysis to the success and unsuccess factors of such implementation must be carried [5].

A study published by Hamid [6] states that the success or unsuccess factors must be categorized as one of the following:

<u>External</u>

- Customer – relation with the customer and its feedback
- Governmental – applied legislation, government changes

<u>Internal</u>

- Top Management – support, resources availability
- Training – for the workers to understand lean principles
- Workers – workers involvement, motivation issues
- Work culture
- Communication – ability to spread information within the organization
- Resources – financial, human
- Development of continuous improvement thinking

The decision for the application of lean principles in an area of the organization is directly related to the experience of success or unsuccess. A study published by AlManei, Salonitis et al. [5] proposes that success or unsuccess factors can be categorized in some of the categories shown above and adds others like organization awareness, commitment of top management, external consultants support, adoption of a strategic approach and realistic milestones.

A study conducted by Antosz and Stadnicka groups the unsuccess factors in a different manner, it states that the most common unsuccess factor is the excessive work experienced by operators, followed by the lack of commitment by workers, the resistance to change, unknowledge of lean principles, lack of motivation, shortness of investment and the top management lack of involvement [7].

Some investigators prefer to refer this factor as facilitators or inhibitors for lean implementation, calling them CSF – Critical Success Factors [4]. Despite the differences in nomenclature, these authors confirm that companies with better performance are those who can adopt a proactive thinking in problem resolution [8].

2.3 Lean implementation strategies

The best way to implement Lean principles in SMEs is doing it step by step according to investigators due to lack of resources [2]. A plan proposed by literature is the *Lean Staircase*.

<u>Lean Staircase [5]</u>

This plan is divided in two phases, an investment phase and an improvement one.

In the investment phase is given priority to a strategic implementation, regarding the definition of specific goals the company wants to achieve. During this phase, it is expected the company to spread lean thinking among its structure, no only at top management but also at operations level. It's a phase where funding and support must be found from external sources and the strategic and investment plans need to be reformed. The investment phase corresponds to the time gap between lean principles adoption and obtaining results from the techniques implemented. The last steps from the performance investment phase are the diagnosis of the production system and the application of some basic lean tools like 5s or VSM.

The performance improvement phase relates to a more operational intervention, corresponding to the phase where results can be obtained. It starts by developing change support mechanisms such as performance metrics. It is succeeded by the application of more complex lean tool like TPM, Kanban or kaizen. This phase ends with the adoption of other supporting initiatives like IT systems and the integration of suppliers in the lean initiative. For continuous improvement the implementation plan suggests that the company has to continuously reset its goals and review them along time [4].

There are other implementation plans suggested in literature. One defined by Sunder et at. [9] suggests that the implementation should start by defining milestones for the goals the company wants to achieve and simultaneously do the VSM and diagnosis of the production system. The author then suggests the implementation of lean tools like cell production, SMED, Kanban. The plan ends once like the *Lean staircase*, with the continuously review of the objectives.

Every plan analyzed has the diagnosis stage in common. This diagnosis can be done two ways, with a lean assessment tool – LAT - or by doing a presential diagnosis in the shop floor. Some aspects included in lean diagnosis are the part lead time, OEE or VSM determination. The LAT has limitations to its applicability like the existence of accurate statistical data [1].

2.4 Suitability of lean techniques in SMEs

Because of the characteristics of SMEs, involving some financial limitations, lack of skills of some operators some lean techniques can not be suitable of implementing in SMEs [2,5]. Studies published refer that the Six Sigma, FMEA and TQM are not well suitable and the most suitable are 5S, JIT, Pull system, visual management or Poka Yoke [2,10].

3 Case study and methodology

To perform this work, an internship of about two months was realized. The company was founded in 1978 and since then has produced machined parts for mold structures.

To elaborate the diagnosis and take the most advantage of the time available, a methodology was defined, and it is represented in Figure 1.

The first step was to understand the production system, identify critical aspects and decide which analysis to perform for each aspect. Once that done, the diagnosis contemplated timing of setups, machining parts were monitored, the existing records were analyzed, some machining programs were monitored, and instant observations were conducted. With that information an analysis of the setups procedures, lead time determination, OEE determination and an work stations analysis were performed.

With the collecting period terminated the problems associated with every aspect analyzed were identified and the root causes determined. That allowed to propose some lean solutions that had the objective of minimizing the impact of the problems identified during the diagnosis.

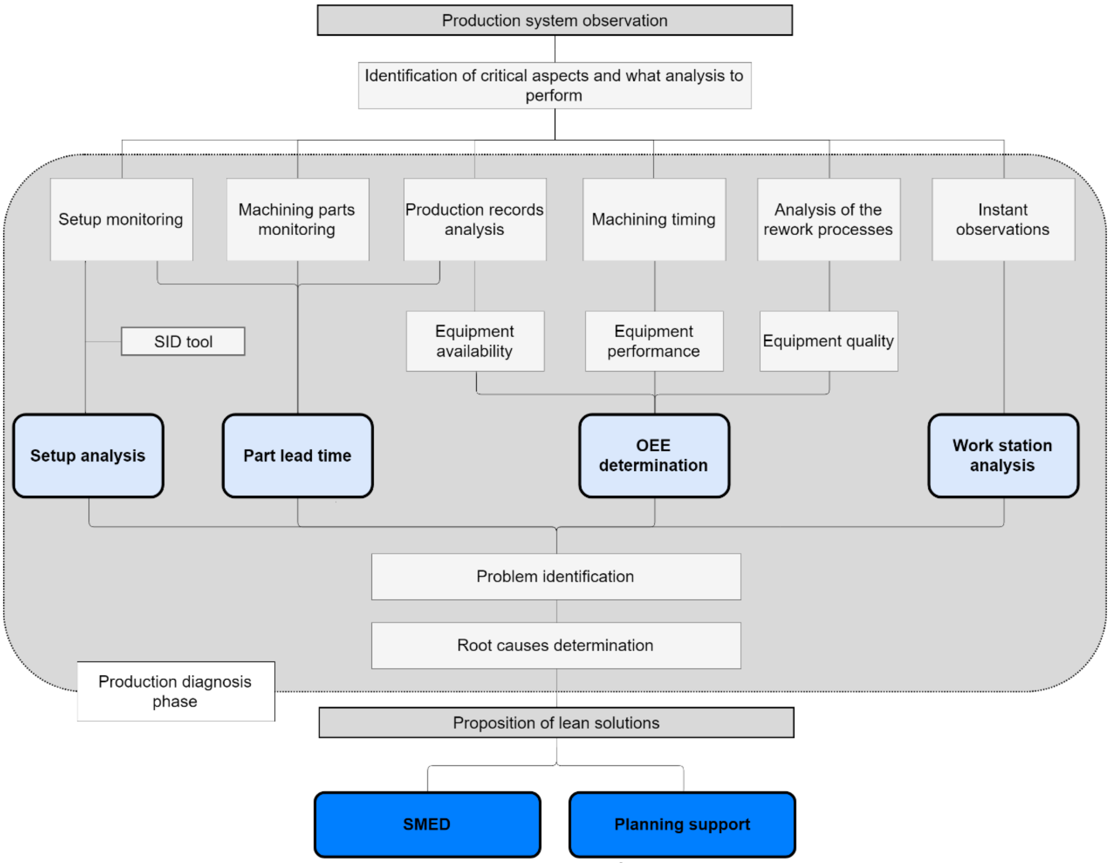

Figure 1 Diagnosis plan flow chart

4 Diagnosis

4.1 Lead time

All parts produced by the company are made by order and each order is identified by the prefix “OM” which means *Obra Moldante*. Two orders were monitored, each comprising three pieces. These two orders were requested in duplicate, so they had the exact same pieces, each containing a #4001, a #6001 and a #8001 piece.

The two pieces #4001 were machined at the same time and in the same machine, with the lead time represented in Figure 2. The detailed data for the lead time of these two pieces is in Table 1. The production of the parts took 268 hours, and 51,9% of them were with the machine waiting due to lack of information from the client regarding specific holes that had to be drilled in the bottom of the pieces. There were also 32,5% of waiting time for the dimensioning operator to control the pieces. In general, the production of these two pieces had an added value contribution (AV) of about 15,1% and non-added value contribution of 84,9%.

Lead time	**268 hours**	
Programming	9 h	3,4%
Setup	1,4 h	0,5%
Machining	34,7 h	13,0%
Machine waiting	139,0 h	51,9%
Part waiting	87,2 h	32,5%
Dimensioning	5,7 h	2,1%
Total	268 horas	100%
Total AV	40,4 h	15,1%
Total NAV	227,6	84,9%

Table 1 #4001 Lead time contributors

A similar analysis was performed for the #6001 and #8001 pieces and the detailed data is in Table 2.

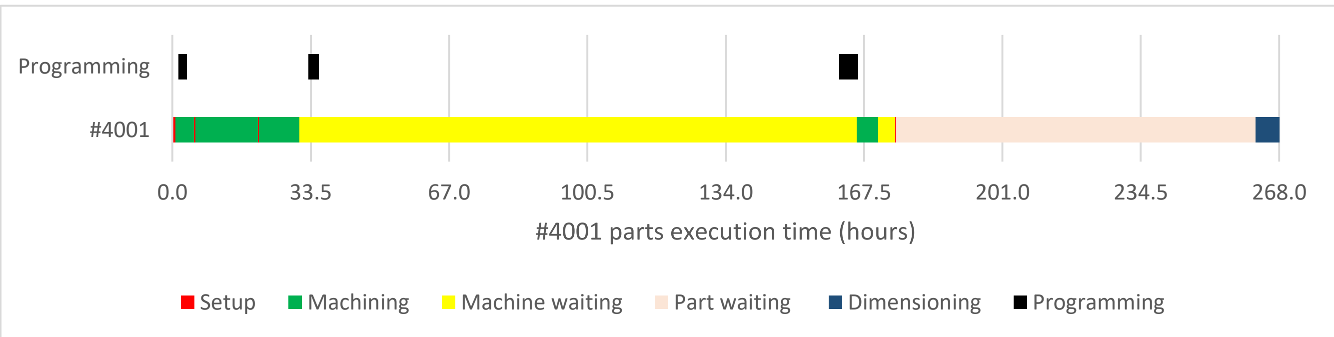

Figure 2 #4001 parts lead time

	#6001	#8001
Lead time	539h	
Programming	6,5%	1,0%
Setup	1,7%	1,7%
Machining	16,5%	17,0%
Machine waiting	11,0%	23,0%
Part waiting	70,4%	58,1%
Dimensioning	0,4%	0,2%
Total	100%	100%
Total AV	16,9%	17,2%
Total NAV	83,1%	82,8%

Table 2 #6001 and #8001 lead time contributors

The lead time of these four pieces took 539 hours to complete. The part waiting stands out of the remaining lead time contributors with an incidence of 70,4% and 58,1% for #6001 and #8001 pieces, respectively. The machining time for these pieces is very low, representing about 17% of total lead time for all pieces. The non-added value contributors represent about 83% of the lead time.

The lead time analysis concluded that the waiting time while the pieces were in production was very high, there was a big difference between the time expected for the machine to conclude the work and the real one verified, and the ratio AV/NAV was very low. After a 5 Why's analysis the root causes were determined, being: ineffective production and maintenance planning and ineffective management of human resources.

4.2 Setups

The setup analysis was made by monitoring 26 setup procedures in both CNC and conventional equipment. The results for the CNC's are represented in

Figure 3.

The setups analysis was performed with the SID tool, which allows the comparison of different setup procedures. It categorizes all tasks done by the operator in categories like movement, transport, cleaning, tool, adjust, positioning, program and unsuitable operation.

For the setups monitored it is evident that there is a big variation in both total times and partials for the SID operations. For instance, considering setup 18 we verify that it lasted for 245 minutes as for setup 19 it took only 73, this is a big difference having in consideration that it is the same machine and the same type of part being introduced.

The variation of SID operations is also relevant. The variation of cleaning operations varies from 8% to 24%, movement operation varies from 8% to 46%, transport varies from 1% to 25%, positioning operation from 3% and 20%, adjust from 4% to 40%, tool from 0% to 23% and program operation from 8% to 72% considering CNC equipments.

For the conventional equipments the same problems were verified.

The setups analysis allowed to determine the problems that were causing the high level of time waste in non-essential tasks that were performed by operators during the time machines were stopped. To determine the high duration of SID operations, a 5 Why's analysis was performed. It concluded that the root causes for this was the inexistence of enough tools both in number and variety to equip all the machines, the lack of organization of the space available around the machines, the inexistence of a standard setup procedure, the lack of organization of the storage of tools and other items.

4.3 OEE

The CNC equipments were the ones analyzed because of their relevance in the production process. The OEE, Figure 5, contemplates three aspects: availability, performance and quality. For the total time available it was considered that the equipments were able to work 24 hours per day and every days of the week, this time constituted the time available which was named TDT – *Turnos com Disponibilidade Total*.

For the availability, the results showed that in average the machines were being used 34% of the time, or about one third of the time available. The availability of machines varied from 24% to 53%. Values above 33% are in line with the usage of machines after operators leave the factory, as they are only

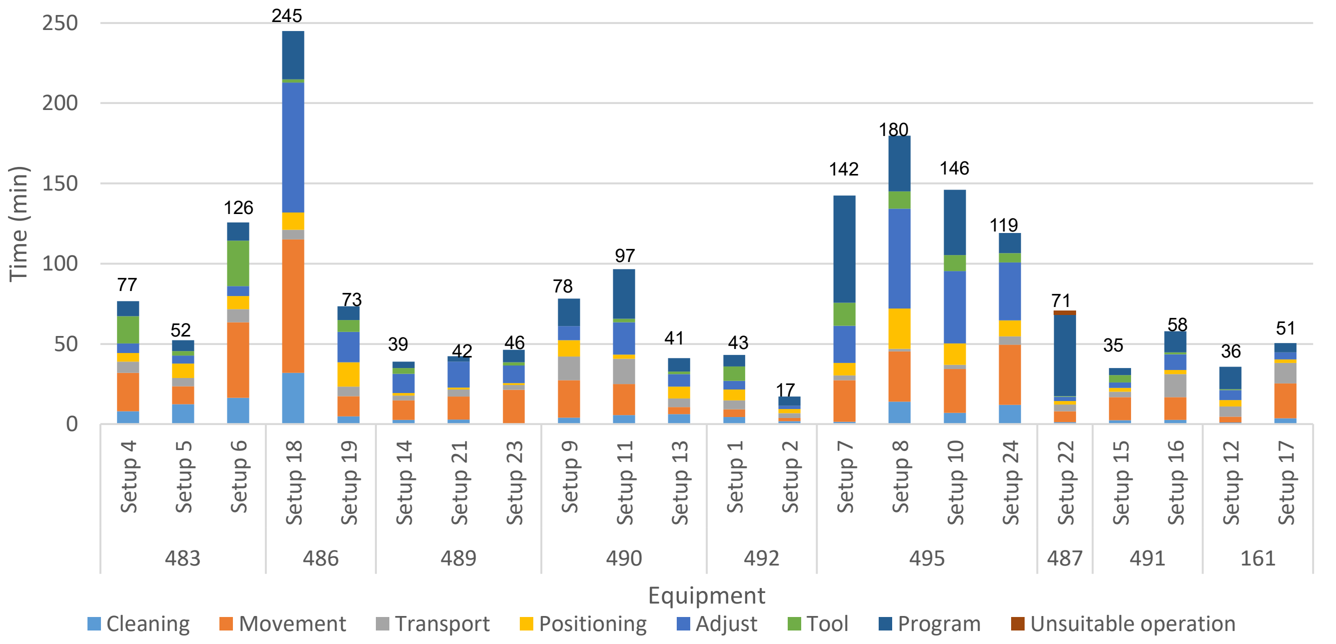

Figure 3 CNC setups results graph

there for one third of the time available in the 9 hours shift. The results for availability of equipments are in Figure 4.

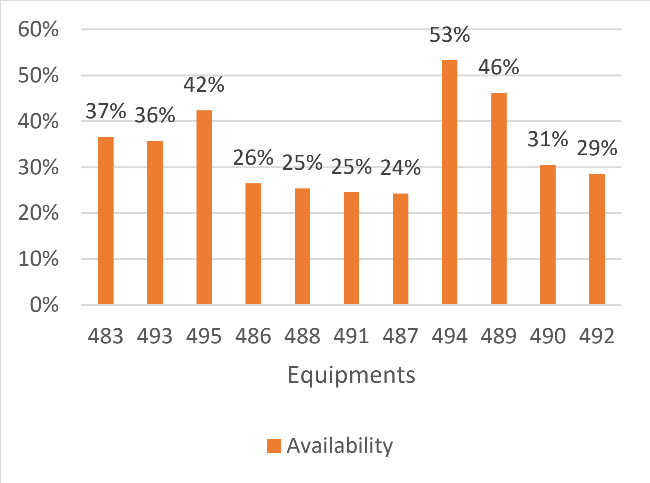

Figure 4 Availability of CNC equipments

The components of the available time are machine running, machine in setup, machine waiting, machine in maintenance, machine broken and machine in idle. The incidence of this components in the time available has high variation among the equipments analyzed. It was verified that there no maintenance incidence pattern and a high incidence of broken time in some machines like the 488, 490 and 491. The low values of availability are caused mainly because of the high machine idle times.

The performance of equipments varied from 46% to 91% and only two of them had values above 80% and about half lower than 65%. The average performance was about 67%. Once again, a 5 why's analysis was made to conclude about the root causes of the low performance values problem, caused by the lowering of machining speeds by the operators. It was verified that the root causes were the ineffective management of human resources, there was not given enough training for the operators to assist the equipments and it was not met any periodic maintenance schedule.

The quality of equipments was considered equal for all of them. This was due to the lack of information and data registered in the production management software. The quality value was calculated analyzing the rework processes done by external services. It was concluded that in one year were contracted 38 external services, each with one piece, in a universe of 1400 pieces produced. This ration resulted in the value of 97,3%. The OEE results are in Figure 5.

The analysis of the work stations corroborated some of the problems of the other analysis. For instance, the low values of availability are in line with the presence of operator in the work station, which is very low considering that this analysis was

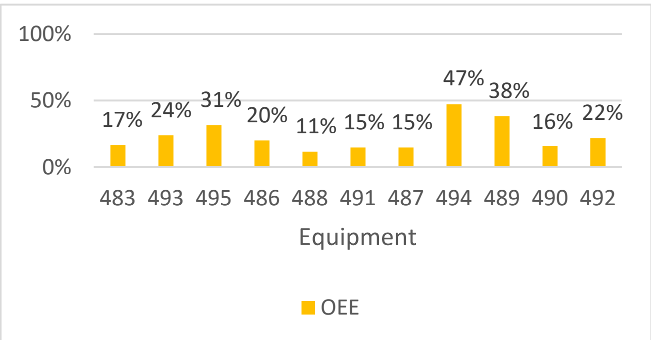

Figure 5 OEE of CNC equipments

only performed when there were operators in the factory. It was also verified that machine setup time is very high with an average incidence of 18%. On the other hand, the maintenance of machines is very low with an average of 1%, this was good if the maintenance activities were performed during the night shift, although this is not verified. About the machine waiting times it was verified that in some equipments this incidence had values of over 50%. The running machine incidence had values between 29% and 79%. Similar analysis about the operators allowed to verify that they were out or the work station about 49% of the 9-hour shift and in 12% of that time they were doing transport operations, 2% were in the chief's office and 86% in unknow location.

5 Solutions

After determined the root causes for the identified sources of waste, this work proceeded with the developing of solutions that aim to minimize them.

5.1 Implementation plan

As verified in the bibliographic review lean transformations need to be mapped in time to guarantee success. So, a lean implementation plan was defined by adapting the Lean Staircase plan reviewed. About the first to fifth stages referred in *Lean Staircase*, it is needed that the company revise their organizational structure and rightly divide the responsibilities between top management and production chief. It is also necessary that the company seek for new ways of funding to support some of the solutions suggested by this work. The sixth stage of Lean staircase suggested that it is a diagnosis time, and that was already done by this work.

The plan proposed by this work is about the last stage of the Investment phase of Lean Staircase and the first and second stage of the second phase. It is scheduled to last twelve months divided in three phases. The plan is schematically represented in Figure 6.

In the first phase it is expected the factory to implement the logic of 5S, and for that is necessary that capital is invested in purchasing some tools and accessories for all the machines that are missing. For that, is mandatory that inventories are made to determine what's necessary. This implementation is to be made during the first phase but should be audited periodically in the remaining phases of the plan. Also, during the first phase the factory should implement visual planning and standardization of filling production records. This standardization needs the operators to be taught about how to use the software the most effective and easy way. It is suggested that the factory to do workshops about the software and if necessary involving the software developer in this training sessions. The daily kaizen could be progressively introduced in the first phase but there won't be the necessary rigorous and trustworthy results obtained with the standardization of records to discuss. Nevertheless, it can be implemented during the first phase to discuss the progress of the other actions to be implemented.

In the second phase is expected the factory to implement SMED and strategies of problem solving like the A3 report and 8D. The strategies of problem solving can be discussed during

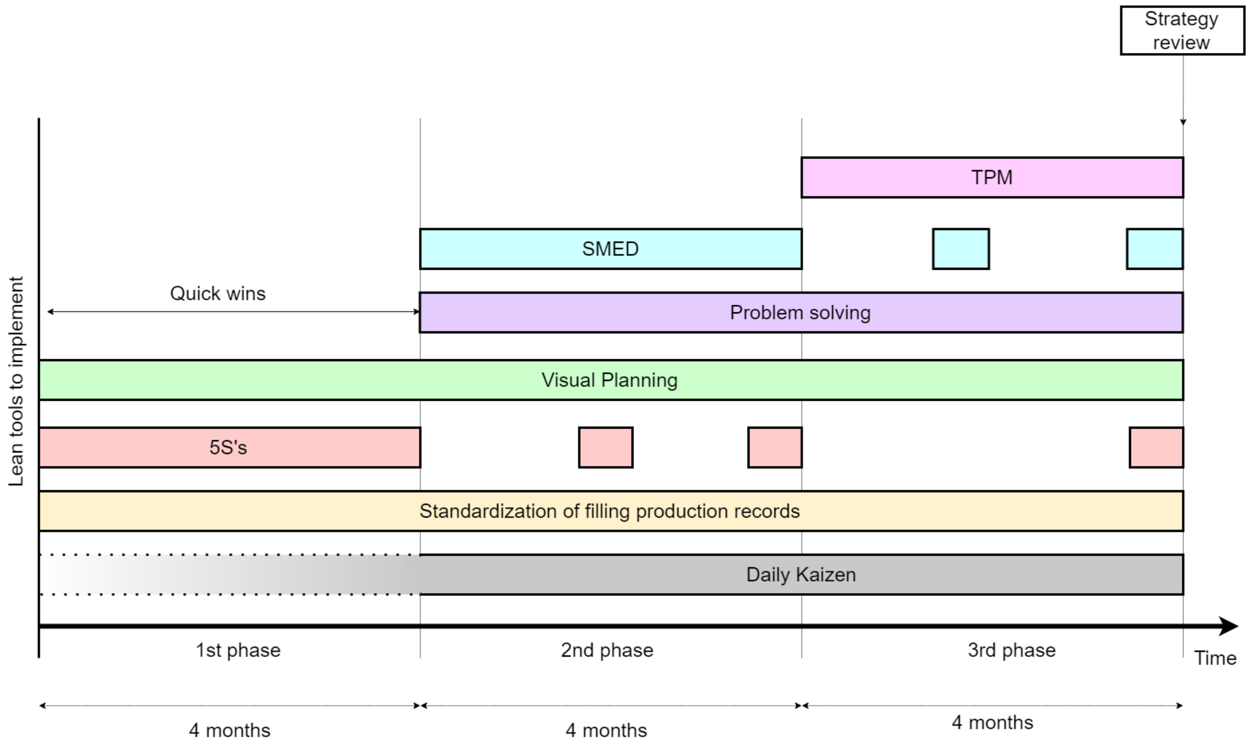

Figure 6 Implementation plan proposed

kaizen events with the operators if necessary. They are a good tool to discuss problems that can be identified during implementation and to come up with solutions. This allows to increase the motivation of operators and delegate in them some of the responsibilities. The kaizen, which must be fully implemented at this phase, needs to happen in both daily period and occasionally with kaizen events. The kaizen events can be used to define the necessary KPIs to visually expose to the factory in the daily kaizen. Also, during the daily kaizen is suggested to expose the planning about production or maintenance schedule, the setups duration, equipment availability and part lead time.

In the third phase the top management is expected to implement TPM, if necessary relying to external maintenance services. It is suggested to introduce the concept of self-maintenance among operators for the simplest actions. Once again this allows to increase motivation of workers and the delegation of responsibilities.

The remaining solutions proposed in first and second phases are supposed to be continued and to audit them along way.

This implementation plan aims to minimize setups duration with SMED implementation and decrease part lead time with intervention in planning, increasing AV/NAV ratio. This plan also aims to increase the equipment OEE acting in planning and maintenance. Concerning the organizational culture, the plan predicts the dissemination of lean philosophy and continuous improvement. This is very important to guarantee the success of the implementations [8].

5.2 SMED

The implementation of a standardized setup procedure aims to minimize the total time the machine is stopped to change piece. The setups monitored during the diagnosis phase were analyzed with the SMED tool, represented in Figure 7. This allowed to divide the operations performed by the operator in internal and external, meaning that all activities that could be done with the machine running were external and those which

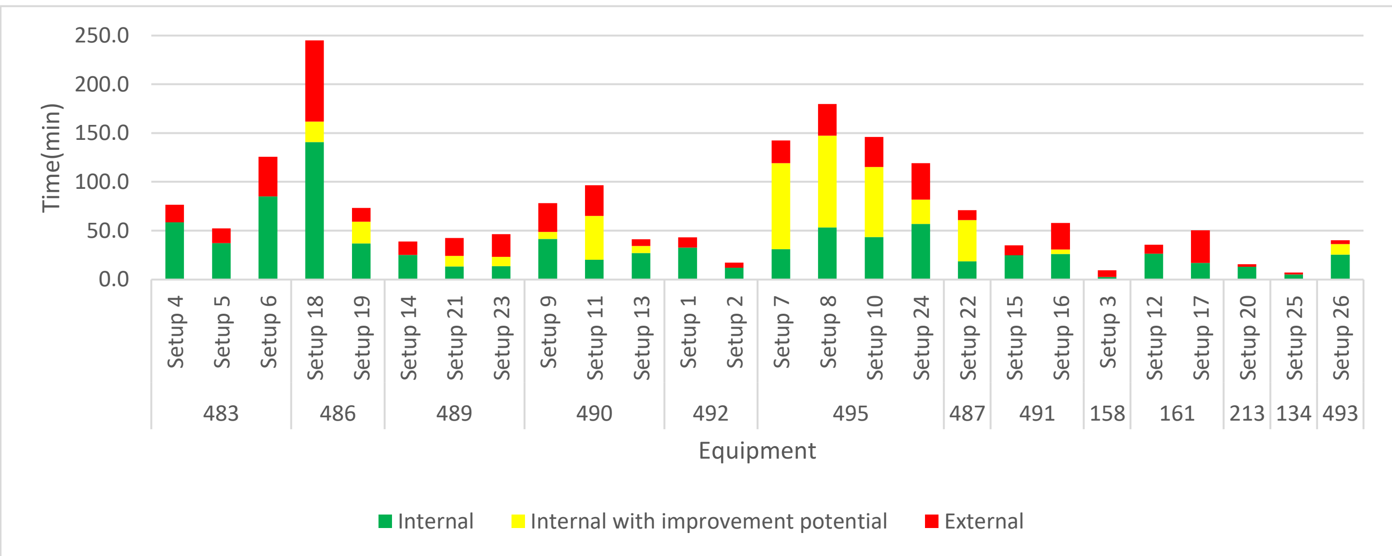

Figure 7 SMED analysis results

could not were internal, this corresponded to the first and second stages of SMED tool. Due to the kind of internal activities analyzed some of them were categorized as internal that could be minimized, this corresponded to the third stage of SMED.

To eliminate the time of external activities from the setup procedures and minimize the internals, were defined three setup related procedures, a pre-setup, a setup and a post-setup procedure.

The pre-setup is related to the preparation of all the things a setup requires. It involves the information about the setup and materials gathering like cleaning items and fastening devices. It also involves the preparation of the piece to be put in the machine, like verifying its position, defining clamping system and verify the dimensions of the piece. Also, during the pre-setup, it is required that the operator to transport the piece from its location to the work station, to perform the cleaning of the piece to be putted in the machine, prepare all related to tools and verify the CAM program.

The setup procedure is done with the machine stopped. During this time, the operator must control the dimensions of the piece that will exits the machine, to remove its clamping fixtures and the piece, clean the interior of the machine, position the new piece and define centers of the new piece to introduce this information in the CAM program. Also, during this time, it is required to insert the tools prepared during the pre-setup and select machining programs.

After the setup the operator must perform a post-setup procedure that aims to do storage of the items used during the setup.

The implementation of the procedures would result in a decrease of an average of 23 minutes with the elimination of external activities represented in red in the graph of Figure 7, corresponding to the second stage of SMED tool. In general, it is expected a reduction of 31% of total setup time, varying from 10% to 72%.

The improvement of the internal operations, related to the third stage of SMED, is expected to minimize total setup time by 18% to 79% with an average of 49%. The global results are exposed in Figure 8.

5.3 Planning support

As verified during diagnosis, planning decisions were a major reason to much of the wastes identified, both in production or maintenance level. Because maintenance planning is a subject for TPM, in this solution is only approach the production planning. For that, there were compared two planning situations, one with the rules used by the factory and other with new rules proposed by this work.

To compare the two situations, it was required that a job matrix was defined, and the one used had 16 parts and two possible machining operations, roughing and finishing. The time available to complete the machining of each part is named TD – *Tempo disponível*. Job matrix used is shown in Table 3

Part	Roughing (h) Machine 483	Finishing (h) Machine 495	TD (h)
1	8	3	24
2	4	5	24
3		15	84
4		8	36
5	7	4	36
6	8	7	96
7	10	6	48
8	10	9	48
9	1	9	108
10	3	3	60
11	3	1	60
12	9	4	120
13	1	8	72
14	1	8	72
15	8	8	132
16	4	5	132

Table 3 Job matrix

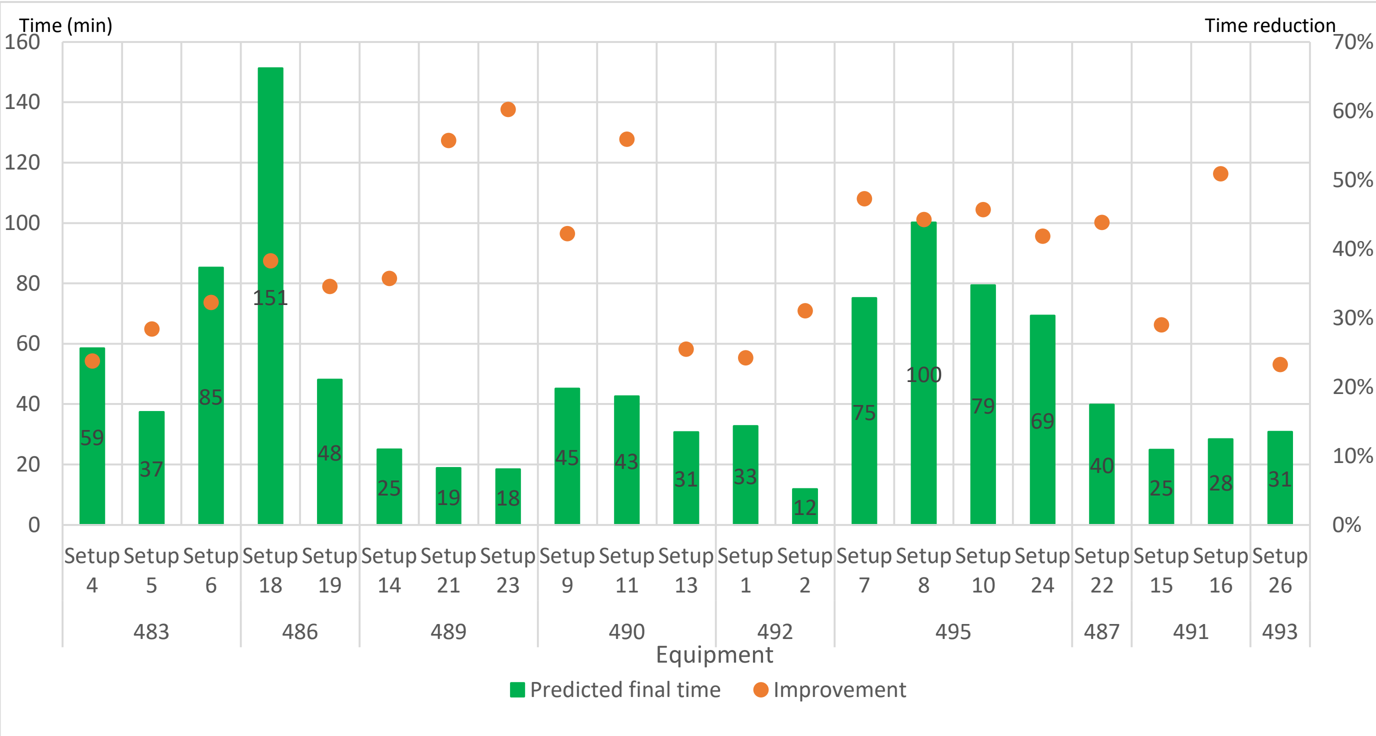

Figure 8 Results of SMED implementation

Because the purpose of this is only to compare the decision priorities during planning definition, some assumptions were fulfilled:

- Setups would only happen during dayshift with operator, from 8am to 5pm, and not during lunch time between 1pm and 2pm
- Setup times are equal for both cases, lasting 1h
- Machining times are the ones from budget
- It is not considered TPM improvements for the machines

To compare each case, it was defined some KPIs, like part lead time (LT), average lead time (LTm), availability of equipments (Ava.), ratio between nightshift usage and nightshift available (blind shift), ratio of pieces delivered with delay, difference between TD and LT (Difference) and ratio between LT and TD (TD usage).

In present days the factory had just one decision planning rules, which was the time available to complete machining operations for the piece and a machining principle, roughing in machines with less performance and finishing in machines with higher performance

The results of the KPIs for the decision rules used by the factory are exposed in Table 4.

Part	LT (h)	Difference (h)	TD usage
1	28	-4	117%
2	33	-9	138%
3	166	-82	198%
4	9	27	25%
5	53	-17	147%
6	176	-80	183%
7	61	-13	127%
8	82	-34	171%
9	186	-78	172%
10	100	-40	167%
11	102	-42	170%
12	149	-29	124%
13	111	-39	154%
14	129	-57	179%
15	207	-75	157%
16	198	-66	150%
Average	112		149%

Table 4 KPI results for factory planning

Planning with factory decision rules resulted in LTm of 112 hours and a delay in 15 pieces, or 94%. Also, the usage of available time (TD) is about 149%, which means machining of parts usually takes more 49% than the available time. In terms of machine results, this planning resulted in 48% and 50% of availability for machine 483 and 495, respectively. Blind shift usage is 31% for 483 and 29% for 495.

The decision rules proposed aim to increase availability of equipments, assuring its maximum usage considering the job matrix and the available time to machine the parts. The ones defined are:

1. Maximization of setups performed in dayshift (giving preference to small machinings during dayshift
1. Maximization of nightshift usage
2. Smallest time available to complete parts

These rules consider the machining process to be performed in one single machine, eliminating the need of a second setup for the same part. The second decision rule is the best one out of two possibilities between the maximization of daily setups and the usage of nightshift and last decision rule is bases on the time available to machine each part.

Once these rules are based on the machining on a single machine, it is necessary to calculate the time necessary to perform the complete machining process in both machines for each part. So, a performance ratio between both machines needs to be calculated and it was based on the performance values from performance analysis during OEE calculations. The ratio of the 483 performance and the 495 performance results in the value of 0.62. This value needs to be reviewed when performance improvements will be obtained from TPM. The time necessary to perform the single machining process on each machine for each part was calculated from the results of Equation 1 and Equation 2.

$$Total\ time_{483} = Machinning\ time_{483} + \frac{Machinning\ time_{495}}{Performance\ ratio}$$

Equation 1 Total time for machine 483

$$Total\ time_{495} = Machinning\ time_{483} * Performance\ ratio + Machinning\ time_{495}$$

Equation 2 Total time for machine 495

The updated job matrix with both possibilities of machining for each part is shown in Table 5.

Part	Total time 483 (h)	Total time 495 (h)	TD (h)
1	13	8	24
2	12	7	24
3	24	15	84
4	13	8	36
5	13	8	36
6	19	12	96
7	20	12	48
8	25	15	48
9	16	10	108
10	8	5	60
11	5	3	60
12	15	10	120
13	14	9	72
14	14	9	72
15	21	13	132
16	12	7	132

Table 5 Updated job matrix

The results of the KPIs for the decision rules proposed are exposed in Table 6.

Part	LT (h)	Difference (h)	TD usage
1	105	-81,0	438%
2	8	16,0	33%
3	46	38,0	55%
4	110	-74,0	306%
5	129	-93,0	358%
6	26	70,0	27%
7	69	-21,0	144%
8	24	24,0	50%
9	65	43,0	60%
10	30	30,0	50%
11	6	54,0	10%
12	83	37,0	69%
13	87	-15,0	121%
14	135	-63,0	188%
15	48	84,0	36%
16	56	76,0	42%
Average	64		124%

Table 6 KPI results for decision rules proposed

Planning with decision rules proposed resulted in LTm of 64 hours and a delay in 6 pieces, or 38%. Also, the usage of available time (TD) is about 124%, which means machining of parts usually takes more 24% than the available time. In terms of machine results, this planning resulted in 76% and 67% of availability for machine 483 and 495, respectively. Blind shift usage is 68% for 483 and 55% for 495.

5.4 Models validation

It was verified that some of the external and internal factors proposed by Hamid [6] did had some influence in the diagnosis results obtained. Problems related with the top management can be categorized in the Hamid's proposal as for the planning and decision-making process is concerned. Another evidence of Hamid's factors is the existence of operator issues related to the assistance of the machines resulting in the decrease of the performance value for equipments. The resources availability is also a concern that was verified, and it is in line with Hamid's proposal.

About the implementation plan, it was verified that the solutions tools proposed had to be adapted to the company as predicted, like SMED, and implemented with realistic milestones [5]. The involvement of operators is also taken into account, assuring their motivation and development of a lean thinking philosophy [2]. It is also considered the involvement of top management, assuring its elements to be completely focused on the objectives and with their responsibilities [7].

6 Conclusion

This work started with a review of some models presented by investigators that tried to categorize the factors that a lean implementation in SMEs depended on. A convergent analysis was made, comparing each model and its categorization, revealing common aspects and its differences. Also, it was analyzed the adaptability of lean tools in SMEs. A lean implementation plan was also reviewed.

A necessity verified in the bibliographic review stated that it was necessary to perform a lean diagnosis to evaluate a production system and to be able to identify its added value stages and quantifying the waste and identifying its sources. To do that, setups were monitored, the lead time of parts was characterized, the OEE of CNC equipments was calculated and it was performed an analysis of the work stations.

The major problems identified were high incidence of waiting times in part lead time, high times of setups and for each SID operation and low values of equipment availability and performance.

To minimize the impact of some of the problems identified during diagnosis phase, some lean solutions were proposed like a lean implementation plan, SMED and a production planning support. The SMED solutions aim the decrease total setup times and increase organization of work stations. The planning support aimed to increase machine availability and increase the OEE. An impact study was performed for each of the proposed solutions with better results than the ones verified during the diagnosis phase. The implementation plan was adapted to the company and its reality, assuring the minimization of the unsuccess risk according to the unsuccess factors proposed by models of various investigators addressed.

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